

**Exam 2**  
**Physics 130**

**Short Answer Section. Please answer all of the questions.**

1. A 4000 kg automobile moves around a curve of radius 10 m. If its tires provide the centripetal force of 40,000N, what velocity does it have?

$$F_c = \frac{mv^2}{r}$$
$$v = \sqrt{\frac{F_c r}{m}} = \sqrt{\frac{40000N \cdot 10m}{4000kg}}$$
$$= 10m / s$$

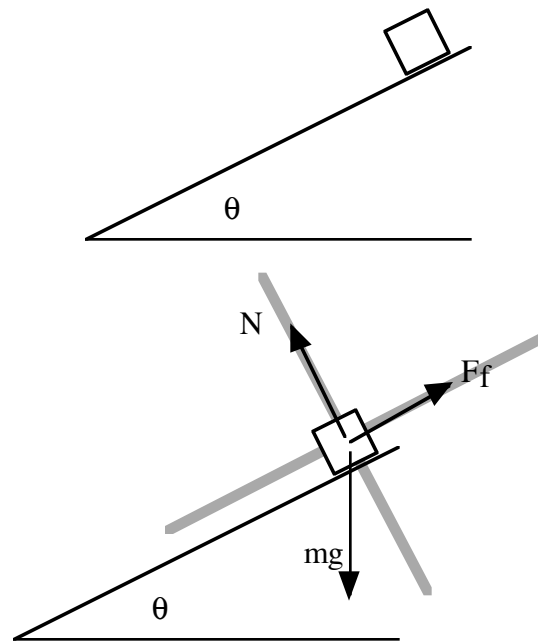
2. A 1000 kg elevator that is suspended by a single cable is accelerating **downward** at  $0.2 m / s^2$ . What is the tension in the cable?

$$a = -0.2m / s^2$$
$$ma = T - mg$$
$$T = ma + mg = 1000kg \cdot -0.2m / s^2 + 1000kg \cdot 9.8m / s^2$$
$$= 9600N$$

3. A golf ball is hit from the ground with a velocity of 80m/s at an angle of 30 degrees. How long does it take to get to its maximum altitude and how far horizontally has it traveled when it reaches its maximum altitude?

<i>x - direction</i>	<i>y - direction</i>
$x_i = 0$	$y_i = 0$
$x_f = ?$	$y_f = ?$
$v_{ix} = 80 \cos 30 = 69.28m / s$	$v_{iy} = 80 \sin 30 = 40.00m / s$
$v_{fx} = v_{ix}$	$v_{fy} = 0$
$a_x = 0$	$a_y = -g$
$v_{fy} = v_{iy} + a_y t$	
$0 = v_{iy} - gt$	$x_f = x_i + v_{ix} t + \frac{1}{2} a_x t^2$
$t = \frac{v_{iy}}{g} = \frac{40m / s}{9.8m / s^2}$	$x_f = 0 + v_{ix} t + 0 = 69.28m / s \cdot 4.082s$
$= 4.082s$	$= 282.8m$

4. A mass  $m$  slides down an incline at constant speed. The incline makes an angle  $\theta$  with horizontal. Friction is present. Draw ALL the forces on the mass. What is the coefficient of friction?



$$mg \sin \theta = \mu mg \cos \theta$$

$$\mu = \tan \theta$$

5. A mass of 100 kg is acted on by three forces:  $\vec{F}_1 = 100\hat{i} + 450\hat{j}$ ,  $\vec{F}_2 = 150\hat{i} + 250\hat{j}$  and  $\vec{F}_3 = 200\hat{i} + 350\hat{j}$ . Find the net force and the acceleration in i, j, k components.

$$\vec{F}_1 = 100\hat{i} + 450\hat{j}$$

$$\vec{F}_2 = 150\hat{i} + 250\hat{j}$$

$$\vec{F}_3 = 200\hat{i} + 350\hat{j}$$

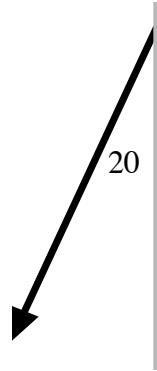
$$\begin{aligned} \vec{F}_{net} &= (100 + 150 + 200)\hat{i} + (450 + 250 + 350)\hat{j} \\ &= 450\hat{i} + 1050\hat{j} \end{aligned}$$

$$\vec{a} = \frac{\vec{F}_{net}}{m} = \frac{450\hat{i} + 1050\hat{j}}{100\text{kg}}$$

$$= 4.50\hat{i} + 10.50\hat{j}$$

6. You are driving at 30 miles/hr and you notice that raindrops are making an angle of 20 degrees with respect to vertical out your side window. Assume that the rain falls straight down when you are watching it from your car when it is stationary. How fast are the raindrops rain falling?

Raindrops on your window

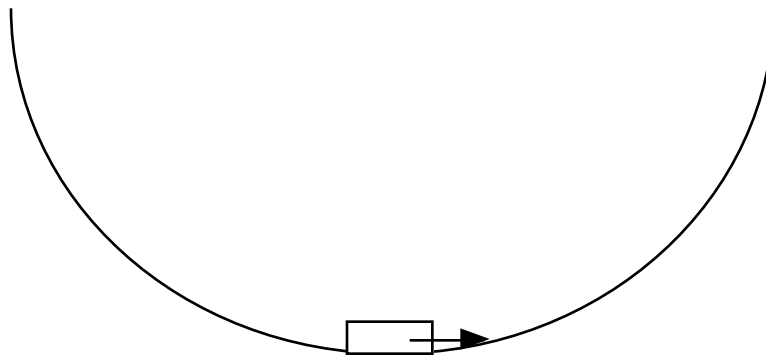


$$\tan 20 = \frac{v_{car}}{v_{falling}}$$

$$v_{falling} = \frac{v_{car}}{\tan 20} = \frac{30}{\tan 20}$$

$$= 82.42 \text{ mi / h}$$

7. A sled slides on the bottom of an icy circular valley of radius 30m. The mass of the sled is 5 kg and its speed is 10 m/s at the bottom. Draw the forces and compute the normal force on the sled. You may assume that this is a uniform circular motion problem. There is no friction.



$$\begin{aligned}
ma &= N - mg \\
ma &= F_c = \frac{mv^2}{r} \\
\frac{mv^2}{r} &= N - mg \\
N &= \frac{mv^2}{r} + mg = \frac{5\text{kg} \cdot (10\text{m/s})^2}{30\text{m}} + 5\text{kg} \cdot 9.8\text{m/s}^2 \\
&= 65.67\text{N}
\end{aligned}$$

**Long Problems. Please work two of three.**

1. A projectile is fired from a table with an angle of 20 degrees with respect to horizontal. The magnitude of its velocity is 3 m/s. The table is 1m high.

a) How long does it take for the projectile to reach its maximum height. ?

<i>x - direction</i>	<i>y - direction</i>	
$x_i = 0$	$y_i = 1\text{m}$	$v_{fy} = v_{iy} + a_y t$
$x_f = ?$	$y_f = ?$	$0 = v_{iy} - gt$
$v_{ix} = 3 \cos 20 = 2.819\text{m/s}$	$v_{iy} = 3 \sin 20 = 1.026\text{m/s}$	$t = \frac{v_{iy}}{g} = \frac{1.026\text{m/s}}{9.8\text{m/s}^2}$
$v_{fx} = v_{ix}$	$v_{fy} = 0$	$= 0.1047\text{s}$
$a_x = 0$	$a_y = -g$	

b) What is its maximum height?

$$\begin{aligned}
y_f &= y_i + v_{iy}t + \frac{1}{2}a_y t^2 \\
y_f &= 1\text{m} + 1.026\text{m/s} \cdot 0.1047\text{s} - \frac{1}{2} \cdot 9.8 \cdot (0.1047\text{s})^2 \\
&= 1.054\text{m}
\end{aligned}$$

c) How long does it take to fall from its maximum height to the ground? What is the total time of flight?

*y* - direction

$$y_i = 1.054m$$

$$y_f = 0$$

$$v_{iy} = 0m/s$$

$$v_{fy} = ?$$

$$a_y = -g$$

$$y_f = y_i + v_{iy}t + \frac{1}{2}a_y t^2$$

$$0 = y_i + 0 - \frac{1}{2}gt^2$$

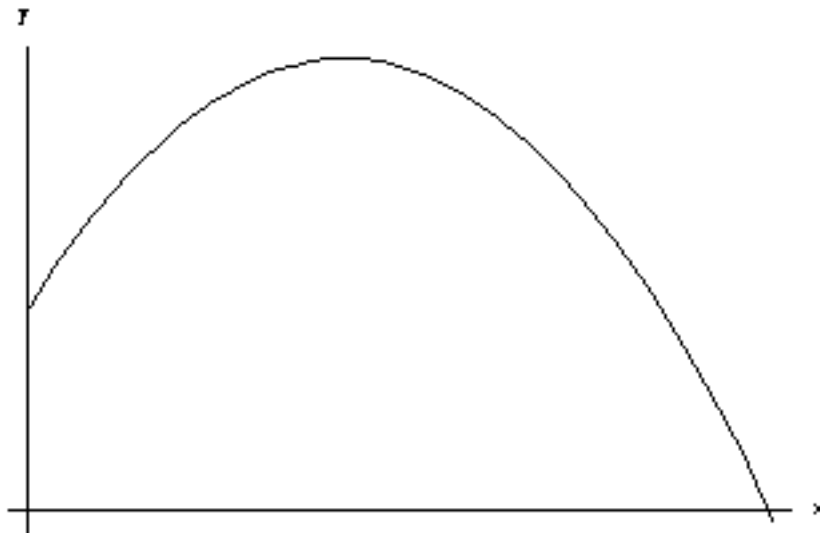
$$t = \sqrt{\frac{2y_i}{g}} = \sqrt{\frac{2 \cdot 1.054m}{9.8m/s^2}} = 0.4648s$$

$$t_{total} = 0.1047s + 0.4648s \\ = 0.5685s$$

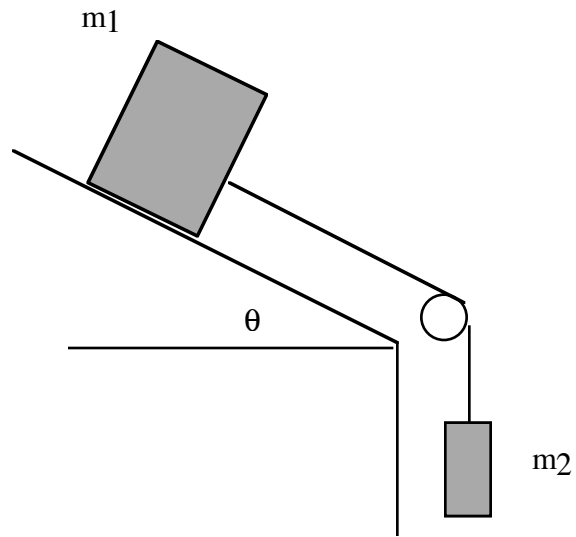
**d)** Where does it land?

$$x_f = x_i + v_{ix}t + \frac{1}{2}a_x t^2$$

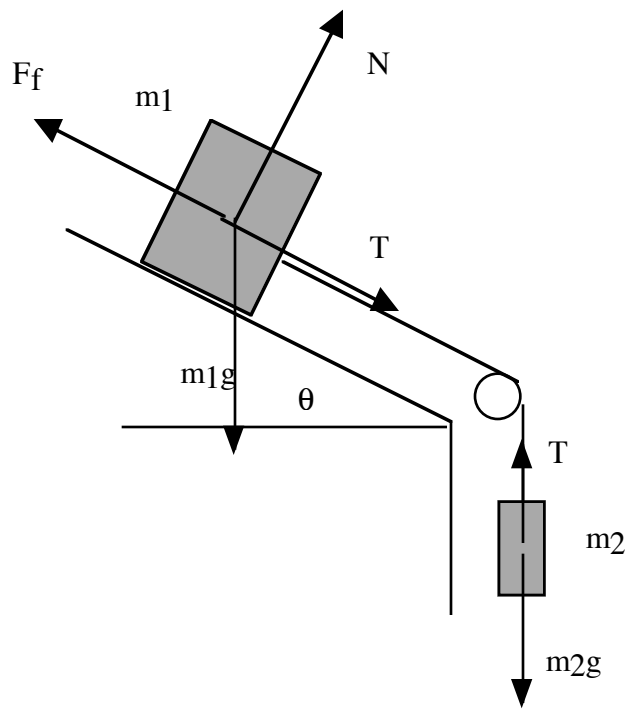
$$x_f = 0 + v_{ix}t + 0 = 2.819m/s \cdot 0.5685s \\ = 1.6026m$$

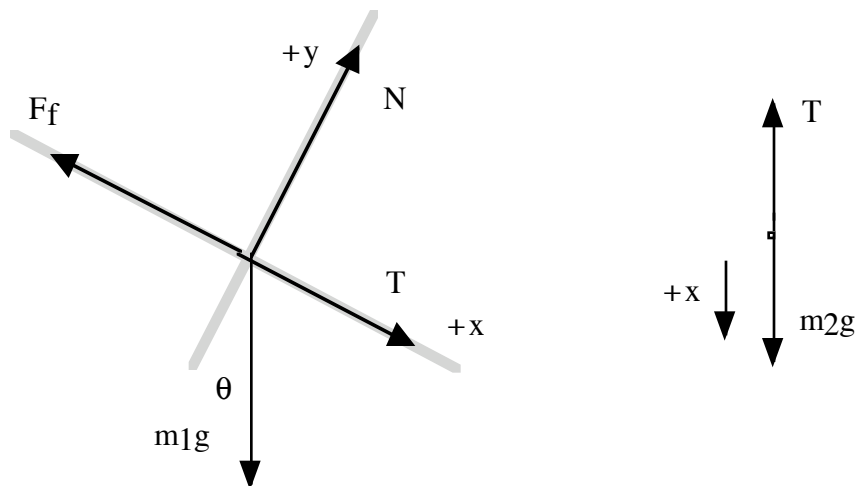


**2.** Consider the masses below. Friction is present with coefficient  $\mu$ .



a) Draw the forces on each block and draw a free body diagram for each block





b) Write the net force on each block.

*mass 1*  
*y - direction*  
 $m_1 a_y = 0 = N - m_1 g \cos \theta$   
 $N = m_1 g \cos \theta$   
*x - direction*  
 $m_1 a_x = T + m_1 g \sin \theta - F_f$   
 $= T + m_1 g \sin \theta - \mu N$   
 $= T + m_1 g \sin \theta - \mu m_1 g \cos \theta$

*mass 2*  
*x - direction*  
 $m_2 a_x = m_2 g - T$

c) What acceleration do the blocks experience.

$$m_2 a_x = m_2 g - T$$

$$T = m_2 g - m_2 a_x$$

$$m_1 a_x = T + m_1 g \sin \theta - \mu m_1 g \cos \theta$$

$$= m_2 g - m_2 a_x + m_1 g \sin \theta - \mu m_1 g \cos \theta$$

$$a_x = \frac{m_2 g + m_1 g \sin \theta - \mu m_1 g \cos \theta}{m_1 + m_2}$$

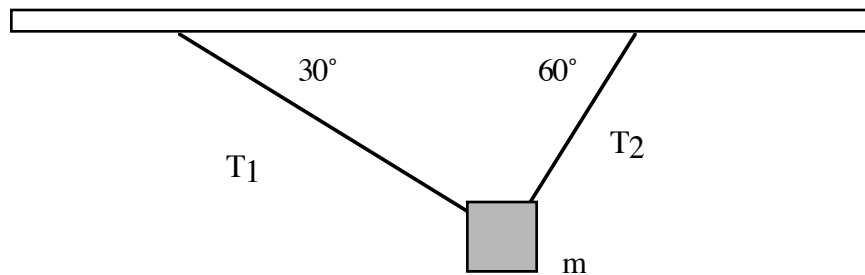
d) What coefficient of friction is necessary for the blocks to move at constant speed?

$$0 = \frac{m_2 g + m_1 g \sin \theta - \mu m_1 g \cos \theta}{m_1 + m_2}$$

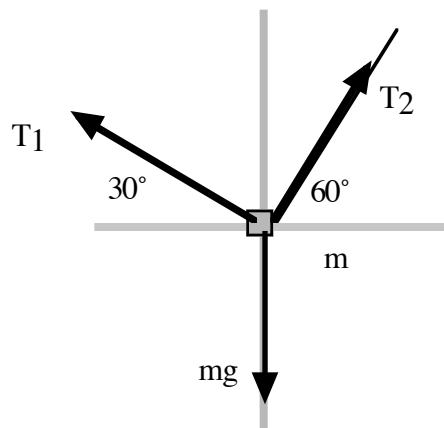
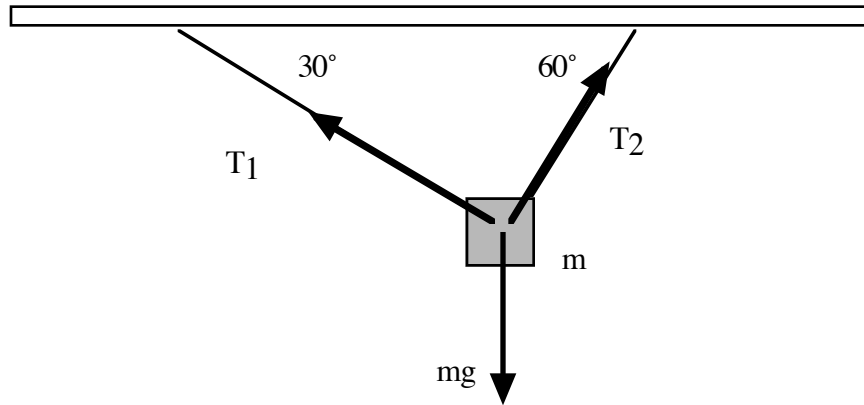
$$0 = m_2 g + m_1 g \sin \theta - \mu m_1 g \cos \theta$$

$$\mu = \frac{m_2 g + m_1 g \sin \theta}{m_1 g \cos \theta}$$

3. Consider a mass suspended by cables as below. The tension  $T_2$  is 2000N



a) Draw a free-body diagram for the mass and write out the equations for the net force on the mass.



b) Find the tension  $T_1$

$$T_2 \cos 60 = T_1 \cos 30$$

$$T_1 = \frac{T_2 \cos 60}{\cos 30} = \frac{2000 N \cos 60}{\cos 30} = 1154.7 N$$

c) Find the weight and the mass  $m$ .

$$0 = T_2 \sin 60 + T_1 \sin 30 - W$$

$$W = T_2 \sin 60 + T_1 \sin 30$$

$$= 2000 \sin 60 + 1154.7 \sin 30$$

$$= 2309.4 N$$

$$mg = W$$

$$m = \frac{W}{g} = \frac{2309.4 N}{9.8} = 235.65 kg$$

d) If you doubled the mass, what Tensions would need to be present?

$$T_2 \cos 60 = T_1 \cos 30$$

$$T_1 = \frac{T_2 \cos 60}{\cos 30}$$

$$0 = T_2 \sin 60 + T_1 \sin 30 - mg$$

$$mg = T_2 \sin 60 + \frac{T_2 \cos 60}{\cos 30} \sin 30$$

$$T_2 = \frac{mg}{\sin 60 + \cos 60 \tan 30} = \frac{471.31g}{\sin 60 + \cos 60 \tan 30}$$
$$= 4000N$$

$$T_1 = \frac{T_2 \cos 60}{\cos 30} = \frac{4000N \cos 60}{\cos 30}$$
$$= 2309.4N$$

e) Assuming that the cables are made of the same material, as you add more and more mass, which cable would break first and why?

The tension in cable 2 is always larger, so it will break first.